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Ecological Studies of Small Vertebrates in Pu-Contaminated Areas of NTS and TTR
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ECOLOGICAL STUDIES OF SMALL

NTS-BIS
ADMINISTRATIVE RECORD #246

VERTEBRATES IN PU-CONTAMINATED

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Concentrations of ^{239}Pu and ^{241}Am were determined in pelt or skin, GI tract, and carcass of 13 lizards and 16 mammals resident on Clean Slate 2, TTR, and Area 11, NTS. A total of 71 animals were collected for radioanalysis. However, the data were not available at the time this report was written. Pu tissue burdens were highest in lizards from Area 11 GZ. Maximum values obtained in nCi/g ash were 30.9, 42.2, and 0.43 for the pelt, GI tract, and carcass, respectively. Maximum ^{239}Pu values in tissues of small rodents from Area 11 (not from GZ) were 11.4, 6.49, and 0.20 nCi/g ash for pelt, GI tract, and carcass, respectively. Pu/Am ratios were relatively consistent in tissue samples of lizards and small mammals from Area 11 (approximately 6:1, Pu/Am). Pu/Am ratios were not consistent in vertebrates of Clean Slate 2, TTR, and appeared to be lower in carcass (28:1, Pu/Am in mammals) than GI tract (9:1, Pu/Am in mammals). Although this trend was more conspicuous in mammals, it was also evident in reptiles.

Average discrimination factor of ^{239}Pu in GI tract and carcass of small vertebrates was in the order of magnitude of 10^{-2} in most instances. Although sample numbers were small (N = 4), reptiles from Clean Slate 2 exhibited an extremely low discrimination rate (5.2×10^{0}).

INTRODUCTION

Studies related to plutonium (Pu) contamination of areas on NTS and TTR have received high priority for current research by the NAEG. In order to determine effects of residual Pu uptake by populations of small animals in a natural area, a intensive, systematic sampling program is necessary.

As part of this research, ecological studies began of biota in NAEG intensive study areas of NTS in March, 1972. These studies have continued since the last formal report (Moor and Bradley, 1974). This report includes analysis of data obtained during October, 1973-September, 1974, from the continuing study of three Pu areas of NTS (GMX and Areas 11 and 13), and preliminary inventories and population studies of four Pu-contaminated areas of TTR (Clean Slates 1, 2, and 3, and Double Track).

During this report period, major emphasis was on census and sampling of vertebrate populations in TTR study areas where few data were available and collection of known resident animals in relation to Pu isopleths and distance from ground zero (GZ) for radioanalysis and histopathological examinations.

Data are also presented on population estimates and recruitment of small vertebrates of four NAEG study areas.

MATERIAL AND METHODS

Study Areas

A checklist of the vascular plants of NTS has been developed by Beatley (1969). Some quantitative vegetation data for NTS and TTR study areas are available (Rhoads, 1974; Romney *et al.*, 1974). Data on the distribution of Pu is contained in reports by Leavitt (1974) and Tamura (1974).

The GMX site (Area 5) is a relatively small (less than one square mile), fenced area which is located in Frenchman Flat. Most of the flora and fauna are characteristic of the lower Mohave Desert (creosote bush community) found in southern Nevada. There is little biotic or topographic diversity.

Area 11 (Plutonium Valley) is the most ecologically diverse of the study areas and is characterized by Beatley (1969) as a *Grayia-Lycium-Tetradymia* community. The biota contains both Mohave and Great Basin elements. The rocky foothills surrounding this small valley and the addition of a tree layer (*Yucca brevifolia*) add to the diversity of the area.

Area 13 (Poject 57 Site) is the northernmost study area of NTS and has strong Great Basin affinities. The vegetation is dominated by *Atriplex spp.*, *Artemesia spinescens*, and *Eurotia lanata*. The fenced enclosure (approximately 900 acres) is located in a large valley which has little natural topographic diversity.

Clean Slate 1, 2, and 3 of TTR are located in Cactus Flats in or near numerous playas. Because cattle were permitted to graze in the valley, the vegetation inside the enclosures is markedly different than that found outside. The most striking difference is the amount of grass (*Hilaria jamesii* and *Oryzopsis hymenoides*) found inside; it is extremely sparse outside. In general, this valley has strong Great Basin affinities and little topographic diversity.

Double Track is located in Stonewall Flat and has strong affinity with the Great Basin Desert. The vegetation is dominated by *Atriplex spp.* and *Artemesia spinescens*. Grasses are not conspicuous in the area, and there is little topographic diversity.

Inventory

The first consideration was a detailed inventory of vertebrate species encountered in NAEG intensive study sites. In general, the vertebrate biota of NTS is well known, with checklists and brief species' accounts readily available (Hayward *et al.*, 1963; Tanner and Jorgensen, 1963; Jorgensen and Hayward, 1965). A preliminary inventory of NAEG areas on NTS has been developed (Moor and Bradley, 1974). However, no vertebrate data from TTR sites were available.

Small mammals, birds, and lizards were inventoried as part of the overall census programs. In addition, incidental observations for other groups, such as snakes and larger mammals and some birds, were recorded in field notes. Both census and field note observations were used to develop a partial species inventory for vertebrates in each study site.

Census and Collection

Whenever feasible, the grid systems developed by NAEG on the study sites were used as locations for census and collection of small vertebrates. Basic grid patterns consisted of numbered steel stakes occurring in parallel lines at 400-ft intervals. In some instances, more detailed grids on a smaller scale were available.

Whenever possible, a census was conducted at regular intervals of approximately two months. In some instances, access to study sites could not be obtained with this regularity due to other scheduled NTS and TTR activities.

Census and collection techniques varied with ease of capture and observation, and have been reported previously (Moor and Bradley, 1974; Moor *et al.*, 1974a).

Reptiles

Census of lizards on the study sites was limited and, in some instances, consisted of developing an index of relative abundance by season for each of the study sites. Relative abundance was based upon a percentage of the total for each species observed during each census period. Line transect counts and relative abundance indices of lizards have been shown to be inadequate estimates of density (Degenhardt, 1966; Pianka, 1970; Medica *et al.*, 1971). However, even a crude index of relative abundance does provide considerable understanding of the composition of the lizard fauna, seasonal activity patterns, and determination of important species for further study.

An alternative census method employed was noosing, marking, and recapture. In general, procedures have been used as described by Medica *et al.* (1971) and (Moor *et al.*, 1974a). The noosing device consisted of a modified fiberglass fishing pole with a noose of surgical thread.

After noosing, lizards were identified, sexed, and classified as hatchling or adult. Individuals were judged to be reproductively active by the presence of breeding coloration in males and by palpation in females. Captives were then marked by means of a system of toe clips and released.

Capture locations for each lizard were recorded in relation to the grid numbers. This allowed ease in recapture and some knowledge of movements and residence in the study sites.

Collections for autopsy and radioanalysis were made of lizards resident in the study sites. Collection techniques employed were by noosing or

use of .22 caliber dust shot. Individuals were then placed in separate plastic bags with identification tags and kept in ice until returned to CETO Laboratory, Mercury, Nevada, and frozen. Individuals of established residence (previously marked at approximately the same location) were utilized for radioanalysis, whereas unmarked individuals collected at known distances from GZ were prepared for histopathological examination by other investigators.

Birds

Birds represent a significant segment of the small vertebrate fauna in NTS and TTR. They are especially abundant and have considerable impact upon desert shrub ecosystems during spring and fall migrations (Miller, 1974). However, few species are resident in the more arid desert ecosystems. Although an important part of the vertebrate fauna, they do present sampling problems due to both their seasonality and high mobility. Residence in study areas can only be determined for breeding birds; therefore, they have not been used for autopsy or radioanalysis. Short-term census and direct observations detailed in field notes provided some basis for developing checklists of bird species for each area.

If it is later found to be desirable to use birds for autopsy or radioanalysis, more detailed studies to determine residence will be needed using techniques similar to those employed by Emlen (1971).

Mammals

Census techniques of mammals varied depending on size, relative importance, and ease of capture or observation. Census of larger mammals (rabbit size and larger) consisted of developing an index of relative abundance by season for each of the study areas. Methods included casual observation and indirect sign such as tracks, scat, burrows, and resting areas. The locations of sight or sign records in the field were recorded in relation to the NAEG grid location numbers. In the present report, these data were used only in the development of checklists.

Small mammal populations were estimated by using live trapping grids as described in Moor *et al.* (1974a). Eight lines of 25 Sherman live traps with each trap 50 ft apart comprised 3.9 hectare grids. Trapping grids were established at various distances from GZ, using the NAEG grid system already established. Permanent live-trapping grids were established in Area 11-C, Clean Slate 2, and Double Track. Grids were trapped three consecutive nights every two months, or whenever access permitted; Double Track could only be trapped for two nights because of U.S. Air Force activities. Live traps were baited with rolled oats.

Mammals captured in live traps were marked with a toe clip and then released. Data recorded at time of capture included the location of the capture in the grid, species identification, toe clip, and notation whether the animal was a recapture, sex, relative age (immature, young adult, or adult), and reproductive condition (testes ascended or descended, pregnant, lactating, or nonreproductive).

The density of small mammals in the trapping grid was estimated using mark-recapture methods described by Hayne (1949) using the formula: $P = CM/R$, P is the population estimate, C is the number of animals captured during the last trapping period, M is the number of marked animals in the area, and R is the number of the marked animals captured during the last trapping period. The trapping grid was also used to gather data on animal movements in order to establish home ranges which were based upon recapture locations in the grid. A center of activity was determined for individual animals using the individual recapture locations and the relative frequency with which an animal is found at various locations in the grid (Hayne, 1949; Calhoun and Casby, 1958). Center of activity was then examined in relation to Pu isopleths and the distance from GZ. Recapture radii were averaged by sex for each species and were used to estimate the effective trapping area of the grid. When sufficient data to estimate recapture radii for a particular species were not available, data from Jorgensen and Hayward (1965) collected from NTS were utilized from similar areas to estimate home-range diameters.

Density estimates were also utilized to compute a species diversity index. The Shannon formula (Shannon, 1948; Pielou, 1966; Lloyd *et al.*, 1968) was used as a general index of species diversity in each study area: $C/N\ (N \text{ Log10 } N - n_i \text{ Log10 } n_i)$ where C converts logs from base 10 to an arbitrary base, N is the total number of individuals of all species, and n_i is the number of the $_i$th species.

In addition to estimates of home range, movements, population densities, and species components found in the study areas, data gathered were utilized for other purposes. Aboveground activity of each species in

recorded. The animals were placed in 10% formalin in plastic gallon jars and shipped to Dr. Gerry Cosgrove, Oak Ridge National Laboratory, Tennessee, for detailed histopathological examinations.

Radioanalysis

Frozen animals individually wrapped in plastic bags were thawed and autopsied in the CETO Lab. Standard measurements and weights were recorded. During autopsy, efforts were made to avoid cross-contamination between animal tissues. Latex surgeon's gloves were worn and discarded after each animal was autopsied, and hands and surgical instruments were washed thoroughly after handling each tissue sample. Small vertebrates were dipped into individual aluminum trays containing hot parafin to minimize the possibility of cross-contamination between pelt or outer skin layer and internal tissues (Lindberg *et al.*, 1955). Individuals were carefully skinned. The carcass was then thoroughly washed with running tap water. After medial-ventral incision through the body wall was made, the gastro-intestinal tract from esophagus to rectum or cloaca was removed intact.

A gross examination of the animal was conducted at this time. Any unusual condition and reproductive status was recorded. The GI tract, carcass, and skin were then placed in separate plastic bags with identification tags, frozen, and sent to LFE Labs for radioanalysis. REECo Rad-Safe personnel handled shipping and recording of data for computer analysis.

RESULTS AND DISCUSSION
POPULATION ECOLOGY

Reptiles

The relative abundance of lizards in NAEG study areas of NTS has previously been reported (Moor and Bradley, 1974). Table 1 presents the relative abundance of lizards in three study areas of NTS and TTR during the report period.

Four species of lizards have been observed in TTR study areas. Two species of insectivorous lizards, *Uta stansburiana* and *Phrynosoma platyrhinos*, are important components of the lizard fauna in all study areas of TTR. One carnivorous lizard, *Crotaphytus wislizeni*, is commonly found in these areas. The above-mentioned lizards are common inhabitants of both Mohave and Great Basin Deserts. Five species of lizards have been observed in the vicinity of the permanent grid in GZ of Area 11-C. One species of insectivorous lizard, *Callisaurus draconoides*, is common to abundant only in gravel areas of the blast centers of Area 11. This lizard is typically found in sandy to gravelly areas of the Mohave Desert. Two other species, the insectivorous *Uta stansburiana* and the carnivorous *Crotaphytus wislizeni*, are common to abundant throughout Area 11.

Table 1. Relative Abundance of Lizards in Three NAEG Study Areas of Roller Coaster Site and NTS (expressed as percent of total number).

	TTR		Area 11-C (Permanent Plot)
	Double Track	Clean Slate 2	
Callisaurus draconoides			21.4
Cnemidophorus tigris	8.3	1.9	2.4
Crotophytus wislizeni	8.3	2.4	7.1
Phrynosoma platyrhinos	25.0	13.1	
Sceloporus magister			4.8
Uta stansburiana	58.3	82.5	64.3
Total Number of Species	4	4	5

Birds

Although birds may represent a temporarily important and dominant vertebrate group during spring and fall migrations in southern Nevada (Hayward *et al.*, 1963; Austin and Bradley, 1971; Miller, 1974), a quantitative census of bird populations was not possible during the report period. Censusing was conducted briefly during 1972-1973 using a strip census method employed by Emlen (1971). The short-term census and incidental observations provided some basis for developing a checklist of bird species in each study area (Appendix I).

The horned lark is the only common-to-abundant resident in NAEG study areas. The more northern areas of NTS (Area 13) and the TTR sites appear to have a rich raptor fauna. The above birds have not been analyzed for Pu uptake and it may be desirable at some later date to utilize these species for autopsy and/or radioanalysis. More detailed studies would then be needed to determine residency.

Mammals

Mammals found in study areas of NTS and TTR are listed in Appendix I and, in general, agree with earlier investigations at NTS (Jorgensen and Hayward, 1965). Population estimates of small vertebrates in NAEG study areas during 1972-1973 have been reported (Moor and Bradley, 1974). Population estimates of rodents at Clean Slate 2, Double Track, Area 11-C, and Area 13 are presented in Tables 2, 3, and 4, respectively.

Investigations of vertebrate populations at TTR were initiated in fall, 1973. Major emphasis has been on census of rodents in these sites. Permanent grids were established in Clean Slate 2 and Double Track in order to estimate densities in and around GZ. At these sites, the enclosures are small in area. Therefore, an important consideration in collection of resident animals was that collection be made when recruitment of young was highest. Sacrificed individuals then had higher probability of being replaced, thus minimizing impact on rodent populations.

There are two important granivores in study areas of TTR, *Dipodomys microps* and, seasonally, *Perognathus longimembris*, both commonly found in Mohave and Great Basin Deserts. In addition, one omnivore, *Ammospermophilus leucurus*, is common in Double Track. There were seven and six rodent species trapped in Clean Slate 2 and Double Track, respectively, during the report period. Two species commonly associated with the Great Basin Desert also occurred. *Spermophilus townsendii* was trapped in Clean Slate 2 and seen in Clean Slate 1. This species has not previously been seen or collected in any NAEG study area. It has been reported from NTS in very small numbers (Jorgensen and Hayward, 1965) and is at its southernmost range extension in NTS. *Microdipodops megacephalus* was trapped in Double Track and Clean Slate 2. It was previously captured only in Area 13, the most northern of the NTS study areas, but had been reported from Kawitch Valley just north of NTS (*op. cit.*).

Table 2. Population Estimates of Rodents in Clean Slate 2, TTR (in number/hectare).

	Nov. 1973	1974			
		March	April	July	August*
Ammospermophilus leucurus					1**
Dipodomys merriami	0.20	0.10	0.05		
Dipodomys microps	0.65	3.16	0.99	1.56	1.55
Microdipodops megacephalus					1**
Onychomys torridus				0.05	2**
Perognathus longimembris		1.30	1.95	2.27	4**
Peromyscus maniculatus				0.05	
Spermophilus townsendii			0.06		
Total Number of Animals	0.65	4.56	3.05	3.93	
Total Number of Species	2	3	4	4	4
Species Diversity (H)	0.79	1.00	1.15	1.15	

*Trapping period was for only two nights.

**Represents actual number caught.

Table 3. Population Estimates of Rodents in Double Track, TTR (in number/hectare, 1974).

Species	1974			
	Mar.	Apr.	Jun.	Aug.
Ammospermophilus leucurus		0.06	0.95	0.41
Dipodomys merriami				0.05
Dipodomys microps	0.19	0.19	0.84	1.04
Microdipodops megacephalus				0.08
Onychomys torridus				0.05
Perognathus longimembris	0.65	0.32	1.30	0.06
Total Number of Animals/ Hectare	0.84	0.57	3.09	1.69
Total Number of Species	2	3	3	6
Species Diversity (H)	0.77	1.35	1.56	1.61

Table 4. Population Estimates of Rodents in Two Study Areas of NTS (number/hectare, 1974).

Species	Area 11				Area 13	
	Feb.*	Mar. 5	Mar. 20	May-Jun.	Apr.	Jun.
Ammospermophilus leucurus	0.65	0.56	5.03	0.47	0.71	0.36
Dipodomys merriami	0.71	0.53	1.40	0.31		0.05
Dipodomys microps	2.50	0.56	0.86	1.86		1.24
Microdipodops megacephalus					0.69	0.23
Onychomys torridus	0.19	0.52	0.47	0.33		

Twelve species of rodents have been trapped in Area 11 since the beginning of the study. During the report period, nine species were trapped in the vicinity of GZ (Area 11-C), all common Mohave Desert animals. Three granivores, *Dipodomys microps*, *Dipodomys merriami*, and *Perognathus longimembris*, and one omnivore, *Ammospermophilus leucurus*, occur abundantly in the study area. In addition, there has been one major change in the rodent fauna in study areas of NTS. *Peromyscus maniculatus* was trapped for the first time in the spring of 1974 in Areas 11 and 13 in relatively large numbers. In May-June in Area 11, density estimates for *P. maniculatus* were 0.93/ha, the third most abundant animal comprising 7% of the rodent fauna. In Area 13 in April, density estimates of *P. maniculatus* were 0.27/ha, the fourth most abundant rodent com-

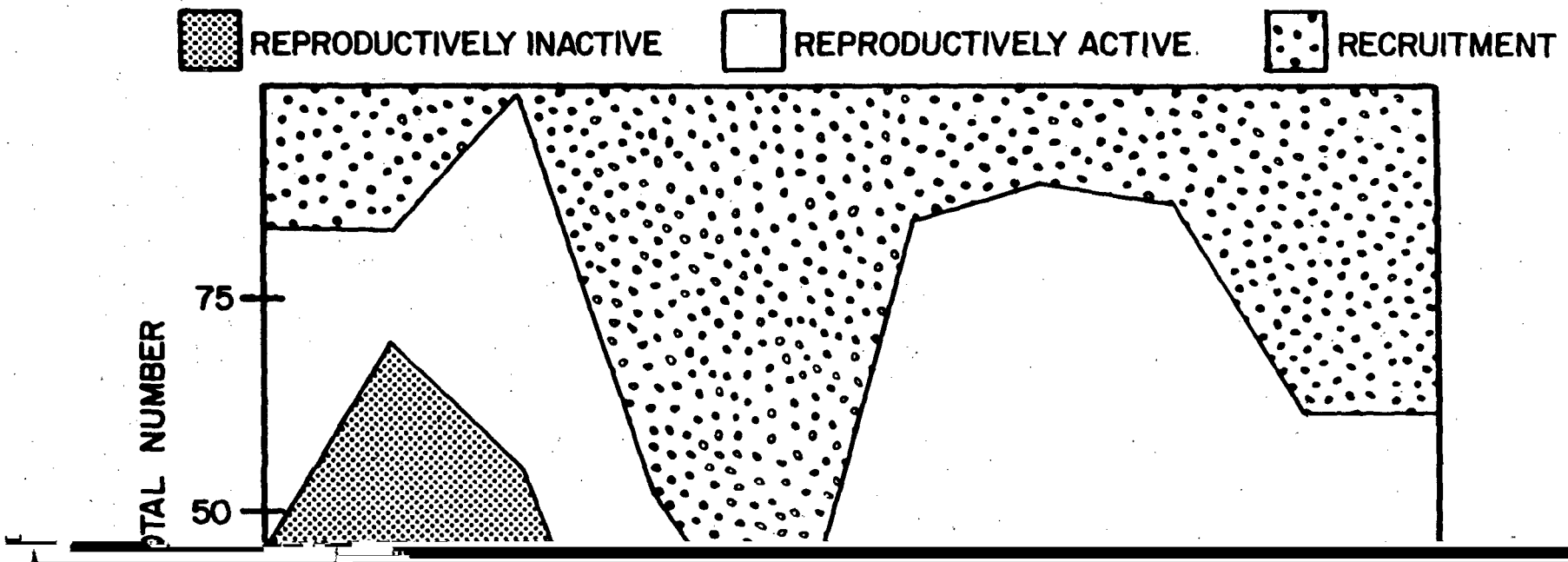

REPRODUCTIVELY INACTIVE
REPRODUCTIVELY ACTIVE
RECRUITMENT
75
50
TAL NUMBER

Table 5. Numbers of Small Vertebrates Collected for Radioanalysis and Histopathological Examination from Six NAEG Intensive Study Areas of NTS and TTR (numbers in parentheses represent animals collected for histopathological examination).

	NTS			TTR		
	Area 5	Area 11	Area 13	Clean Slate 1	Clean Slate 2	Double Track
Reptiles						
Callisaurus draconoides	(7)	3(1)				
Cnemidophorus tigris	1(1)		1		5	
Crotaphytus wislizeni					2	
Phrynosoma platyrhinos	1			1	2	
Uta stansburiana					2(3)	
Pituophis melanoleucus			1			
Mammals						
Lepus californicus		(1)				
Sylvilagus auduboni		1				
Ammospermophilus leucurus		(5)	3			
Dipodomys microps		6(8)	10(2)		13(2)	4(1)
Dipodomys merriami		3(8)	1(3)			
Neotoma lepida	(1)					
Onychomys torridus		3(3)			1	
Perognathus longimembris		1(1)	(4)		1(2)	2(2)
Thomomys umbrinus			1			
Totals	2(9)	17(27)	17(9)	1	26(7)	6(3)

[redacted]

in Area 11, NTS.

Species	No.	^{239}Pu $\bar{x}$ + Range (nCi/g ash)	No.	^{241}Am $\bar{x}$ + Range (nCi/g ash)	Pu/Am Ratio
Callisaurus draconoides					
Skin	3	17.69(7.07-30.90)	2	2.82(1.00-4.65)	
GI Tract	3	18.04(0.32-42.20)	3	2.53(0.05-6.02)	
Carcass	2	0.17(0.12-0.23)	1	0.05	
Cnemidophorus tigris					
Skin	2	3.73(0.16-7.31)	2	0.51(0.02-1.00)	
GI Tract	2	3.71(1.13-6.28)	1	0.18	
Carcass	2	0.23(0.02-0.43)	1	0.06	
Crotophytus wislizeni					
Skin	2	1.09(1.08-1.09)	2	0.17(0.16-0.18)	
GI Tract	2	3.31(0.67-5.94)	2	0.46(0.10-0.81)	
Carcass	2	0.05(0.04-0.06)	1	0.01	
Sceloporus magister					
Skin	1	2.03	1	0.31	
GI Tract	1	1.39	1	0.22	
Carcass	1	0.04	0		
Uta stansburiana					
Skin	1	1.92	1	0.26	
GI Tract	0		1	0.08	
Carcass	1	0.30	1	0.04	
Totals					
Skin	9	7.41(0.16-30.90)	8	0.95(0.02-4.65)	6.85
GI Tract	8	8.69(0.32-42.20)	8	1.12(0.05-6.02)	6.81
Carcass	8	0.16(0.02-0.43)	4	0.04(0.01-0.06)	6.85

of ^{239}Pu in some species are surprising. For example, the average concentrations of ^{239}Pu in skin and GI tracts of three *C. draconoides* were approximately 18 nCi/g ash. The average ^{239}Pu concentrations of the nine lizard samples collected in Area 11 were (in nCi/g ash) skin = 7.41, GI tract = 8.69, and carcass = 0.16. These high levels may be attributed to the area in which the lizards were collected. All individuals were collected in the immediate vicinity of GZ (Fig. 2). A gravel area covers GZ-C which has been monitored and found to exceed 10^8 CPM ^{241}Am. All *C. draconoides* were taken from these gravel areas; other lizards were collected from the periphery of the gravel areas.

Not only were Pu burdens high, but there were low levels of discrimination between Pu burdens in skin, GI tract, and carcass (Table 7). The range of ratios between Pu in GI tract and carcass were in an order of magnitude of 10^0 (2.6) to 10^2 (390) with an average factor of 10^2 (110).

The Pu/Am ratios were consistent in skin, GI tract, and carcass of all lizards analyzed from Area 11 (Table 6). They did not differ significantly in skin, GI tract, and carcass. The mean ratio of all samples in Area 11 was calculated as 6.84.

Data on concentrations of ^{239}Pu and ^{241}Am in small mammals from Area 11 are presented in Table 8. Levels of ^{239}Pu in mammals were not as high as those found in lizards. One possible reason for this difference is that no mammals were collected from GZ and the levels of ^{239}Pu in soil drop drastically with distance from GZ as shown by REECo isopleth map for Area 11. Figure 2 shows activity centers in relation to estimates of ^{241}Am concentrations in each isopleth from which animals were collected. The average ^{239}Pu concentrations in pelt, GI tract, and carcass in all mammals collected in Area 11 (N = 12) were 2.48, 0.94, and 0.03 nCi/g ash, respectively. The ranges in values of ^{239}Pu in all small mammals were: pelt = 0.008-11.400, GI tract = 0.004-6.490, and carcass = 0.0002-0.204.

Six *D. microps* were analyzed for ^{239}Pu and had relatively low levels in tissues. *Dipodomys merriami,* however, had higher levels in the pelt (nCi/g ash) ($\bar{x}$ = 4.87, max. = 11.40), GI tract ($\bar{x}$ = 3.26, max. = 6.49), and carcass ($\bar{x}$ = 0.16, max. = 0.022).

Table 7 presents the relative uptake of ^{239}Pu in pelt, GI tract, and carcass. The discrimination rate between GI tract and carcass averaged 187 and ranged from a factor of 10^0 (3.8 to 10^3 (1,036). One individual had a higher level of Pu in the carcass than the GI tract and two individuals had higher levels in GI tract than pelt.

Pu/Am ratios were higher in pelts (6.95) of mammals from Area 11 than ratios in GI tract (5.94) and carcass (5.83). However, since some tissue samples were missing, these values may not be directly comparable. The average Pu/Am ratios for all mammal samples was 6.25.

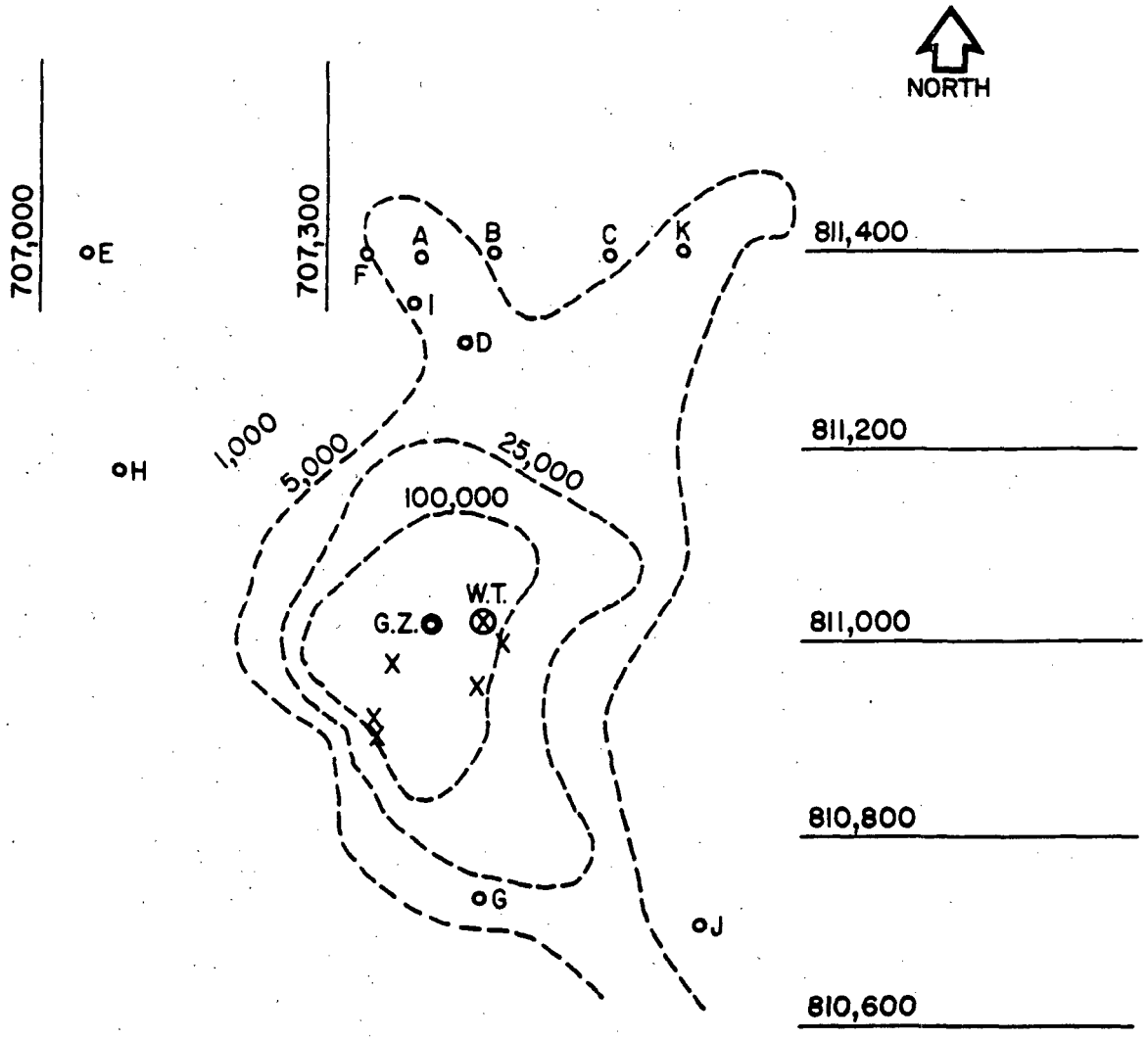


Figure 2. Centers of Activity of Small Mammals (O) and Lizards (X) in Relation to CPM ^{241}Am Isopleths in Area 11-C, NTS. Code for Animals:

Dipodomys merriami E, G, H
Dipodomys microps A, B, C, D, K
Onychomys torridus J
Perognathus longimembris I
Sylvilagus auduboni F

Table 7. Average (Discrimination Factor) of ^{239}Pu in Skin or Pelt, GI Tract, and Carcass of Small Vertebrates in Three Study Areas of NTS and TTR (in nCi/g ash).

Class	No.	Clean Slate 2 TTR	No.	Area 11 NTS	No.	Area 13 NTS
Reptiles						
Skin/GI Tract	4	1.3	7	6.9		
Skin/Carcass	4	2.2	5	34.5		
GI Tract/Carcass	4	5.2	5	110.2		
Mammals						
Pelt/GI Tract	3	1.6	8	35.0	9	1.5
Pelt/Carcass	2	128.4	8	225.0	9	350.0
GI Tract/Carcass	2	109.1	8	187.0	9	240.0

Table 8. ^{239}Pu and ^{241}Am in Small Mammals From Area 11, NTS.

Species	No.	^{239}Pu $\bar{x}$ + Range (nCi/g ash)	No.	^{241}Am $\bar{x}$ + Range (nCi/g ash)	Pu/Am Ratio
Dipodomys merriami Pelt	3	4.873(1.30-11.40)	2	0.200(0.18-0.22)	

Areas 5 and 13 and Clean Slate 1

Results from Area 13 samples were not available at the time this report was written. Results from last year for *D. microps* were as follows (N = 9): $\bar{x}$ pelt = 1.05, GI tract = 0.72, and carcass = 0.003 nCi/g ash. The discrimination factor between levels of ^{239}Pu in pelt, GI tract, and carcass were consistent with values of mammals from other NAEG study areas (Table 7). Pu/Am ratios for the nine *D. microps* from Area 13 were pelt = 1.5, GI tract = 350.0, and carcass = 240.0.

Two lizards were analyzed for Pu in Area 5, one *C. tigris* and one *P. platyrhinos*. One *P. platyrhinos* was analyzed from Clean Slate 1. Data are incomplete but are as follows (nCi/g ash): Area 5, *C. tigris* (skin = 0.142); *P. platyrhinos* (skin = 0.271, GI tract = 1.25, carcass = 0.024); Area Clean Slate 1, *P. platyrhinos* (skin = 0.0156, GI tract = 0.006, carcass = 0.002).

Clean Slate 2

Table 9 presents ^{239}Pu and ^{241}Am concentrations in two species of lizards from Clean Slate 2, TTR. Two each of *P. platyrhinos* and *U. stansburiana* had mean values of ^{239}Pu in skin = 0.045, GI tract = 0.103, and carcass = 0.026. The Pu/Am ratios for skin and GI tract were not consistent with those in the carcass. Of interest are the low discrimination rates of Pu between skin, GI tract, and carcass of reptiles in Clean Slate 2 (Table 7). The lowest average rate is found in GI tract and carcass, the difference being a factor of 10^0 (5.1), whereas in Area 11, it is in the order of magnitude of 10^2–10^3. However, tissue burdens are not high when compared to lizards from Area 11.

Four *D. microps* were analyzed from Clean Slate 2 (Table 10). Pu values are higher than values determined for lizards for the skin and GI tract but not for the carcass. Pu/Am ratios were not consistent in skin, GI tract, and carcass. The Pu/Am ratio was lower in the carcass (8.93) than in either the pelt (28.56) or GI tract (14.36). Lizards were generally collected in the immediate vicinity of GZ, whereas *D. microps* were collected further away from GZ. Data on rodents collected from the immediate vicinity of GZ have not been received.

Discussion

Approximately half of the results of radioanalysis were available as of this report writing. Not only were Pu and Am analyses incomplete for each sample, but the data from subsamples, i.e., skin, GI tract, and carcass, were not complete in some samples. It is important to realize, therefore, that these results are preliminary and await statistical analysis and refinement when further data become available. Certain trends, however, appear conspicuous and some discussion is justifiable.

Table 9. ^{239}Pu and ^{241}Am in Lizards From Clean Slate 2, TTR.

Species	No.	^{239}Pu $\bar{x}$ + Range (nCi/g ash)	No.	^{241}Am $\bar{x}$ + Range (nCi/g ash)	Pu/Am Ratio
Phrynosoma platyrhinos					
Skin	2	0.039(0.02-0.06)	2	0.006(<.01-0.01)	
GI Tract	2	0.035(0.02-0.05)	2	0.005(<.01-0.01)	
Carcass	2	0.013(0.01-0.02)	2	0.002(<.01-0.01)	
Uta stansburiana					
Skin	2	0.051(0.04-0.06)	2	0.004(<.01-0.01)	
GI Tract	2	0.170(0.02-0.32)	2	0.009(<.01-0.01)	
Carcass	2	0.040(0.02-0.06)	2	0.005(<.01-0.01)	
Totals					
Skin	4	0.045(0.022-0.062)	4	0.005(0.002-0.011)	10.98
GI Tract	4	0.103(0.020-0.320)	4	0.007(0.004-0.015)	10.64
Carcass	4	0.026(0.059-0.008)	4	0.004(0.001-0.006)	7.49

Table 10. ^{239}Pu and ^{241}Am in *Dipodomys microps* From Clean Slate 2, TTR.

Tissue	No.	^{239}Pu $\bar{x} \pm SE$ (nCi/g ash)	No.	^{241}Am $\bar{x} \pm SE$ (nCi/g ash)	No.	Pu/Am Ratio
Pelt Range	4	0.363 ± 0.092 0.192 - 0.600	3	0.015 ± 0.003 0.011 - 0.020	3	28.56
GI Tract Range	4	0.825 ± 0.660 0.104 - 2.810	4	0.054 ± 0.005 0.005 - 0.188	4	14.36
Carcass Range	4	0.002 ± 0.001 0.001 - 0.003	2	0.0002 ± 0.0001	2	8.93

Distribution of ^{239}Pu and ^{241}Am does not appear to be uniform in species which occupy similar isopleth strata (Table 11). For example, lizards collected from GZ in Area 11 (1×10^8 CPM ^{241}Am) had a range of ^{239}Pu in the carcass of 0.044-0.430, whereas lizards from isopleths of 1×10^7 CPM ^{241}Am ranged from 0.008-0.524.

High values of ^{239}Pu in lizards from GZ of Area 11 have been discussed. Recent preliminary attempts were made to investigate possible sources of this Pu contamination. Arthropod traps were placed in the immediate vicinity of Area 11 GZ. The insects collected were washed with ethanol to remove surface contamination and a gamma scan run by REECo Soils Lab. Estimations of ^{239}Pu in insect tissue, although very preliminary, were 0.5 nCi/g dry weight. Lizards collected from GZ of Area 11 are primarily insectivorous; hence, food supply represents a good source of contamination. These invertebrates, however, are normally covered with dust when eaten by lizards; therefore, we are planning to next pick up arthropods individually and have them gamma-scanned to determine if Am and Pu uptake is primarily from soil or from invertebrate tissue. Additionally, it is common to find soil particles in the GI tract of lizards during stomach analysis. Hence, both ingested food and soil are potential sources of Pu uptake.

It is expected that some general trends will be seen when additional data from these and other isopleths become available. The relationships between tissue burdens of rodents and isopleth strata also are obscure.

In general, however, lizards from isopleths of higher CPM ^{241}Am had higher tissue burdens of ^{239}Pu than rodents from isopleths with lower counts. In addition to the problem of small and incomplete samples, there are some data that suggest that the isopleths determined by FIDLER surveys (CPM ^{241}Am) are not necessarily an accurate indicator of Pu concentrations in surface soil samples (Gilbert and Eberhardt, 1974). When additional data on ^{239}Pu concentrations in soil samples from different isopleths become available, further analysis will be made.

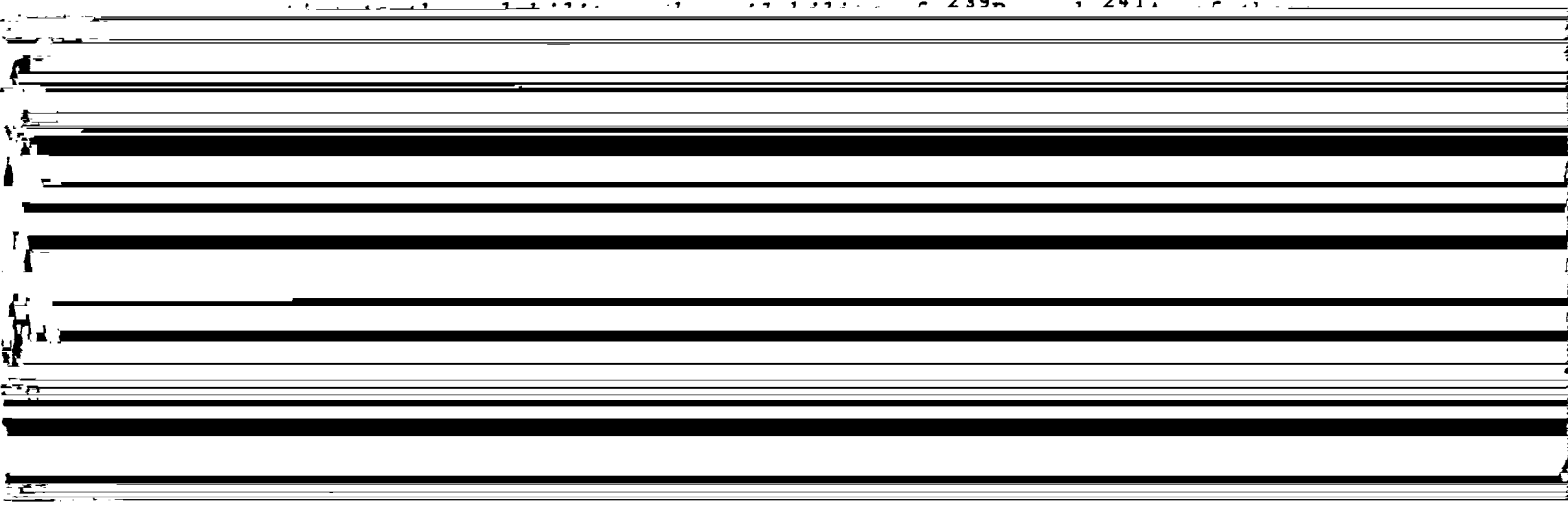
Another consideration when evaluating isopleth strata in relation to animal tissue burdens is the mobility of animals. Unlike plants which can usually be assigned to a definite isopleth strata, animals may move through several isopleths during normal activity and are assigned to strata on the basis of the highest probability of finding an individual in a certain location, i.e., center of activity. With additional data, however, animals may be more extensively analyzed in relation to available Pu. Whereas Pu/Am ratios are consistent in Area 11 in tissue of both small mammals and reptiles (Ca 6/1), ratios from Clean Slate 2 are not (Tables 9 and 10). Mean Pu/Am ratios range from 8.9 in carcass to 28.6 in pelt for mammals, and 7.5 in carcass to 11.0 in skin for reptiles. More data are needed before statistical analysis can be used to predict significance; however, these ratios do not appear to correspond to ratios determined in soil samples from Clean Slate 2 (37 Pu/Am). The difference between animal tissue and soil Pu/Am ratios may

Table 11. The Relationship of Pu in Tissue Samples of Vertebrates to Am Isopleths as Estimated From FIDLER Measurements.

Isopleth Interval (CPM ^{241}Am)	No.	^{239}Pu (nCi/g ash) in Tissue Sample ($\bar{x}$ and Range)		
		Skin or Pelt	GI Tract	Carcass
		LIZARDS		
1,000- 5,000	1	0.062	0.02	0.059
5,000- 10,000	5	0.271(0.022-1.080)	0.438(0.025-1.130)	0.119(0.008-0.524)
50,000-100,000	7	9.346(1.090-30.9)	11.288(0.316-42.200)	0.195(0.044-0.430)
		RODENTS		
0- 1,000	4	3.306(0.075-11.400)	1.778(0.035-6.490)	0.010(<0.001-0.022)
1,000- 5,000	11	1.406(0.008-1.920)	0.672(0.005-4.740)	0.020(<0.001-0.204)
5,000-10,000	4	0.036(0.192-0.738)	0.825(0.104-2.810)	0.007(<0.001-0.020)
10,000-20,000	1	1.780	0.037	0.004

possibly be explained as a preferential Am uptake as has been suggested to occur in plants (Romney *et al.*, 1974; and others). This is speculation because few data are available for animals. However, ratios are lower in carcass than either pelt, skin, and GI tract in both reptiles and mammals.

The radioanalysis data presented in this report are incomplete and, hence, difficult to analyze. Trends in Pu contamination in small vertebrates are not readily apparent. Not only are more analysis of vertebrate samples needed, but sources of contamination such as inhalation, feeding, or through breaks in pelt or skin should be determined and evaluated. For example, the ingestion of ground-dwelling arthropds and soil particles by lizards should be evaluated, particularly in rela-



sources.

HISTOPATHOLOGY

Fifty-five animals were collected from study areas of NTS and TTR and shipped to Oak Ridge Laboratories for histopathological examination (Table 5). None of the animals collected and autopsied exhibited any apparent radiation effects, although few animals which were examined were collected from GZ of the study areas and these were all lizards (N = 7). Efforts will be made to increase collections of resident animals in isopleth strata which have higher CPM ^{241}Am such as GZ of Area 11 and Double Track.

It should be kept in mind that small mammals autopsied to date have ecological life expectancies of approximately one year and are exposed to relatively low doses.

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Appendix I. Checklist of the Vertebrates in Six NAEG Study Areas of the Nevada Test Site and Tonopah Test Range.

Species	Area 5	Area 11	Area 13	Clean Slate 1	Clean Slate 2	Double Track
REPTILES						
Lizards						
Gekkonidae						
Coleonyx variegatus		X				
Iguanidae						
Callisaurus draconoides	X	X				
Crotaphytus collaris	X	X				
Crotaphytus wislizeni	X	X	X		X	X
Phrynosoma platyrhinos	X	X	X	X	X	X
Sceloporus magister		X				
Uta stansburiana	X	X	X	X	X	X
Teidae						
Cnemidophorus tigris	X	X	X	X	X	X
Snakes						
Colubridae						
Masticophis flagellum	X					
Pituophis catenifer	X	X	X			
Salvadora hexalepis	X					
Crotalidae						
Crotalus cerastes	X	X				
Crotalus mitchelli		X				
BIRDS						
Anatidae						
Anas carolinensis (Green-winged Teal)			X			
Anas strepera (Gadwall)			X			

Appendix I (Continued)

Species	Area 5	Area 11	Area 13	Clean Slate 1	Clean Slate 2	Double Track
Cathartidae						
Cathartes aura (Turkey Vulture)	X					
Accipitridae						
Aquila chrysaetos (Golden Eagle)		X	X			
Buteo jamaicensis (Red-tailed Hawk)			X	X	X	
Buteo lagopus (Rough-legged Hawk)					X	
Accipites cooperii (Coopers Hawk)					X	
Circus cyaneus (Marsh Hawk)		X	X	X	X	
Falconidae						
Falco mexicanus (Prairie Falcon)		X			X	
Falco sparverius (Sparrow Hawk)	X	X	X	X	X	X
Rallidae						
Fulica americana (American Coot)	X					
Scolopacidae						
Actitis macularia (Spotted Sandpiper)	X					
Phalaropodidae						
Steganopus tricolor (Wilson's Phalarope)			X			
Columbidae						
Zenaidura macroura (Mourning Dove)	X	X	X			

Appendix I (Continued)

Species	Area 5	Area 11	Area 13	Clean Slate 1	Clean Slate 2	Double Track
Strigidae						
Asio flammeus (Short-eared Owl)			X			
Caprimulgidae						
Chordeiles acutipennis (Lesser Nighthawk)	X	X			X	
Trochilidae						
(Unk. Hummingbird)			X			
Tyrannidae						
Contopus sordidulus (Western Wood Pewee)	X					
Sayornis saya (Say's Phoebe)	X					
Tyrannus verticalis (Western Kingbird)	X	X	X			
Alaudidae						
Eremophila alpestris (Horned Lark)	X	X	X	X	X	X
Hirundinidae						
Stelgidopteryx ruficollis (Rough-winged Swallow)			X			
Corvidae						
Corvus corax (Common Raven)	X	X	X	X	X	X
Pica pica (Black-billed Magpie)	X	X	X			
Troglodytidae						
Telmatodytes palustris (Long-billed Marsh Wren)	X					
Mimidae						
Mimus polyglottos (Mockingbird)	X	X				

Appendix I (Continued)

Species	Area 5	Area 11	Area 13	Clean Slate 1	Clean Slate 2	Double Track
Toxostoma dorsale (Crissal Thrasher)	X	X				
Sylviidae						
Polioptila caerulea (Blue-gray Gnatcatcher)	X					
Poliopitala melanura (Black-tailed Gnatcatcher)			X			
Laniidae						
Lanius ludovicianus (Loggerhead Shrike)	X	X	X	X	X	X
Vireonidae						
Vireo gilvus (Warbling Vireo)	X					
Vireo solitarius (Solitary Vireo)	X					
Ploceidae						
Passer domesticus (House Sparrow)	X					
Icteridae						
Agelaius phoeniceus (Red-winged Blackbird)	X					
Euphagus cyanocephalus (Brewer's Blackbird)			X			
Molothrus ater (Brown-headed Cowbird)	X					
Sturnella neglecta (Western Meadowlark)	X					
Xanthocephalus xanthocephalus (Yellow-headed Blackbird)	X					

Appendix I (Continued)

Species	Area 5	Area 11	Area 13	Clean Slate 1	Clean Slate 2	Double Track
Fringillidae						
Amphispiza belli (Sage Sparrow)		X		X	X	X
Amphispiza bilineata (Black-throated Sparrow)	X	X	X	X	X	X
Calomospiza melanocorys (Lark Bunting)			X			
Carpodacus mexicanus (House Finch)	X	X	X			
Chordestes grammacus (Lark Sparrow)			X			
Melospiza melodia (Song Sparrow)	X					
Passerella iliaca (Fox Sparrow)						
Pooecetes gramineus (Vesper Sparrow)			X			
Spizella breweri (Brewer's Sparrow)		X	X			
Zonotrichia leucophrys (White-crowned Sparrow)	X					
MAMMALS						
Vespertilionidae						
Myotis sp.		X				
Pipistrellus hesperus	X	X	X			X
Sciuridae						
Ammospermophilus leucurus	X	X	X		X	X
Spermophilus townsendii					X	X

Appendix I (Continued)

Species	Area 5	Area 11	Area 13	Clean Slate 1	Clean Slate 2	Double Track
Geomyidae						
Thomomys umbrinus	X					
Heteromyidae						
Dipodomys merriami	X	X	X		X	X
Dipodomys microps	X	X	X	X	X	X
Dipodomys ordii		X	X			
Microdipodops megacephalus			X		X	X
Perognathus formosus		X				
Perognathus longimembris	X	X	X	X	X	X
Perognathus parvus			X			
Cricetidae						
Neotoma lepida	X	X				
Onychomys torridus	X	X	X		X	X
Peromyscus crinitus		X				
Peromyscus eremicus		X	X			
Peromyscus maniculatus		X	X		X	X
Leporidae						
Lepus californicus	X	X	X		X	X
Sylvilagus audubonii		X				
Canidae						
Canis latrans	X	X	X	X	X	X
Urocyon cinereoargenteus		X	X	X	X	X
Vulpes macrotis	X	X	X			
Mustelidae						
Taxidea taxus		X	X	X	X	X
Felidae						
Felis concolor		X				